Claims

1. A method for controlling the simulated interfacing of a first body controlled by a user with a second body, while providing haptic feedback to the user on such interfacing including:

storing selected representations of said first body and of said second body in a processing apparatus; using a user controlled interface device to control simulated movement of the first body relative to the second body;

detecting any collision between the first body and the second body, including the position on each body of each collision, the direction of the collision, and force for the collision;

converting the detected direction, point and force for each collision into at least one force vector on the first body; and

applying said at least one force vector as a corresponding feedback force vector to said interface device, and thus to the user.

2. A method as claimed in claim 1 wherein said interface device controls simulated movement of said first body in at least five degrees of freedom; and

wherein said at least one force vector is in the same at least five degrees of freedom.

3. A method as claimed in claim 1 wherein at least one of said representations is an implicit equation representation of the body.

4. A method as claimed in claim 3 wherein said first body representation is a binary space partition tree representation.

5. A method as claimed in claim 3 wherein force for a collision is represented at least in part by penetration of the body represented by the implicit equation into the other body.

6. A method as claimed in claim 1 wherein at least one of said representations is a point cloud representation of the body.

7. A method as claimed in claim 1 including storing a niceness factor for at least one feature of said first body; and

utilizing the niceness factor to influence said force vector.

8. A method as claimed in claim 1 including defining a guide zone around at least a portion of one of said bodies; and

providing a force feedback to said interface device to urge the first body toward the second body when the bodies are not in contact but the guide zone of the one body is detected as having the other body therein.

9. A method for controlling the simulated interfacing of a first body controlled by a user with a second body not under user control, while providing haptic feedback to the user on such interfacing including:

storing a point cloud representation of at least one of said bodies; and

utilizing said point cloud representation in said simulation.

10. A method for generating CAD/CAM postures for a tool operating on a body including:

storing a representation of the tool and a representation of said body in a computer;

using a user controlled haptic interface device to control simulated movement of the tool relative to the body;

detecting any collision between the tool and the body for a given posture, including the position on each for each collision, the direction of the collision, and the penetration of the tool into the body;

converting the detected direction, point and penetration for each collision into at least one force vector on the tool;

summing the force vectors for a given posture;

applying said at least one force vector as a corresponding feedback force vector to said interface device, and thus to the user; and

storing postures of the tool where the tool collides with the body at a working surface of the tool, but does not otherwise collide with the tool as potential CAD/CAM postures.

11. A method as claimed in claim 10 including determining potential CAD/CAM postures which at least meet selected criteria and storing only such postures.

12. A method as claimed in claim 11 wherein only the best posture for each point on the body is stored.

13. A method as claimed in claim 10 wherein said representation of the tool includes a niceness factor, the niceness factor being higher for regions of the tool where contact is desired, and decreasing for regions as a function of desired contact in such regions.

14. A method as claimed in claim 13 wherein the niceness factor is zero for regions where contact is undesirable.

15. A method as claimed in claim 13 wherein the niceness factor for a posture is the lowest niceness factor for contacts occurring at such posture.

16. A method as claimed in claim 13 wherein said tool representation is divided into regions, a different region being defined at least at each surface transition of the tool, and wherein a niceness factor is assigned to each region.

17. A method as claimed in claim 10 wherein said tool representation is divided into regions, a different region being defined at least at each surface transition of the tool, force direction and magnitude being continuous with each said region.

18. A method as claimed in claim 17 including storing a binary space partition tree representation of the tool for each said region.

19. A method as claimed in claim 18 including storing a point cloud representation of the body.

20. ~~A method as claimed in claim 17 including defining a snap-fit region for said tool around each working, desired contact region thereof.~~

21. A method as claimed in claim 20 including applying a force to said interface device to urge said tool toward the body when the body and tool are not in contact but the body is in a said snap-fit region of said tool.

22. A method as claimed in claim 10 wherein a part is being machined from the body and material is being removed from the body in layers, including establishing constraints at a layer boundaries, and detecting collisions between the tool and a selected operative constraint.

23. A method as claimed in claim 22 including storing implicit equation representations of said constraints and point cloud representation of said tool.

24. A method as claimed in claim 22 wherein collisions are detected between the tool and the part as well as between the tool and the operative constraint, wherein force vectors are generated for each collision, and wherein said summing step sums and averages force vectors for all collisions.

25. A method as claimed in claim 10 including defining a desired orientation for said tool, and applying a suitable force to said haptic device to urge the device in a direction to correct any deviation of tool orientation from said desired orientation.

26. ~~A system for controlling the simulated interfacing of a first body controlled~~ by a user with a second body, while providing haptic feedback to the user on such interface ~~including~~:

at least one memory storing selected representations of ~~said first~~ body and of said second body;

a user controlled hepatic interface ~~device~~; and

processing apparatus ~~responsive~~ to said interface device for providing simulated movement of ~~the first~~ body relative to the second body, said processing apparatus detecting ~~collisions between the~~ bodies resulting from such simulated movement, including ~~the~~

position on each body of each collision, the direction of the collision, and force for the collision, converting the detected direction, point and force for each collision into at least one force vector and, feeding back the at least one force vector through said interface device.

27. A system as claimed in claim 26 wherein said interface device controls simulated movement of said first body in at least five degrees of freedom; and

wherein said at least one force vector is in the same at least five degrees of freedom.

28. A system as claimed in claim 26 wherein at least one of said representations is stored as an implicit equation representation of the body.

29. A system as claimed in claim 28 wherein said first body representation is stored as a binary space partition tree representation.

30. A system as claimed in claim 28 wherein force for a collision is represented at least in part by penetration of the body represented by the implicit equation into the other body.

31. A system as claimed in claim 26 wherein at least one of said representations is stored as a point cloud representation of the body.

32. A system as claimed in claim 26 including a niceness factor stored in said at least one memory for at least one feature of said first body;

said processing apparatus utilizing the niceness factor to influence said force vector.

33. A system as claimed in claim 26 including a representation stored in said at least one memory for a guide zone around at least a portion of one of said bodies;

said processing device providing a force feedback to said interface device to urge the first body toward the second body when the bodies are not in contact but the guide zone of the one body is detected as having the other body therein.

34. A system for controlling the simulated interfacing of a first body controller by a user with a second body, while providing haptic feedback to the user on such interface including:

a memory storing a point cloud representation of at least one of said bodies; and

processing apparatus which utilizes ~~said~~ point cloud representation in said stimulation.

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